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Lepidoptera
Liparidae
Hemerocampa pseudotsugata

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
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REPORT

OF

AN OUTBREAK OF THE DOUGLAS-FIR TUSSOCK MOTH (HEMEROCAMPA PSEUDOTSUGATA)

IN

LATAH AND CLEARWATER COUNTIES, IDAHO 1946

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REPORT OF AN OUTBREAK OF THE DOUGLAS-FIR TUSSOCK MOTH (HEMEROCAMPA PSEUDOTSUGATA) IN LATAH AND CLEARWATER COUNTIES, IDAHO 1946

INTRODUCTION

In 1946, a previously reported outbreak of the Douglas-fir tussock moth appeared throughout a large forest area near Moscow, Idaho. During early summer the feeding caterpillars of this moth were so injurious to the foliage of trees within this area that entire mountain sides appeared brown. These areas which extended from Moscow to Tensed, Idaho, along State Highway 95, aroused considerable public interest as to the possibility of remedial action. On July 15, the Moscow Chamber of Commerce called a meeting of those interested for a full discussion of the situation. This meeting was attended by representatives of the United States Forest Service, the Bureau of Entomology and Plant Quarantine, State Forestry Service, Idaho University forestry and entomology officials, county agents, operating lumber companies, private owners, and interested private citizens. Conclusions drawn were that it was then too late to attempt to obtain funds for control in 1946, but that the extent of the infestation as well as the feasibility and cost of instituting artificial control in 1947 be determined.

The responsibility for this survey and study was assumed by the Forest Insect Laboratory at Coeur d'Alene, Idaho, and its fulfillment made possible through the cooperation of the Forest Service. Later in the season a forester was appointed by the regional forester as his representative, to assist in bringing together the many physical phases of this project considered necessary for a complete report.

The report which follows is not complete in that far more information must be obtained in the event that artificial control methods are to be instituted. It has been prepared with the idea of presenting the entomological, physical, and economic factors associated with this problem which must all be evaluated in determining the advisability of control. An attempt has been made to keep this report as brief as possible without sacrificing information necessary in the presentation of the complete picture.

DESCRIPTION, SEASONAL HISTORY, AND HABITS OF THE DOUGLAS-FIR TUSSOCK MOTH

The Douglas-fir tussock moth (Hemerocampa pseudotsugata) is perhaps the most important forest foliage feeding insect of the northwestern United States. This insect has been reported from Nevada, Idaho, Oregon, Washington, and British Columbia, and is no doubt present in other states.

Adult moths appear the latter part of August and are present throughout most of September. The female is wingless, having but two short, rudimentary stumps of wings. Her body is from 1/2 to 5/8 of an inch or more in length, and is covered with a mat of dark grey hairs. The abdomen is large and packed with eggs which are full formed upon the emergence of the adult. Soon after emergence the females are fertilized and her eggs are laid in a mass on top of her own cocoon. These masses are covered with a frothy gelatinous secretion in which are embedded the hairs from her body.

The adult males have well-developed wings which are from 1 to 1-1/4 inches in width when expanded. The fore-wings are dark, greyish chocolate brown on the upper side with two irregular dark bands. White scales, appearing as irregular spots, are distributed more or less evenly on the upper surface of the fore or primary wings. The hind wings and the underside of the fore-wings are a light, uniform rusty brown with darker marginal shadings.

The mature caterpillars of the tussock moth are striking looking creatures, decorated with brightly colored tufts of hairs. When full grown they are from 3/4 to 1-1/4 inches in length. There are two tufts of black hairs directly behind the head which are at least 1/4 inch in length. A similar but somewhat longer tuft of black hair stands at the posterior end. There are also short tufts of hairs as well as numerous red spots on the body of the caterpillar, with lateral, light colored stripes along the sides. There are two distinct body colors, one a light fawn and the other greyish. The fawn-colored caterpillars seem to be somewhat larger and it is thought that they may be the females, but this has not been established.

The eggs are spherical in shape and approximately 1/25 inch in diameter. The number of eggs in a single mass will vary from 75 to 125 or more.

There is but one generation of this insect each year. Eggs are laid in late August and September which overwinter and hatch in late May or early June depending entirely upon variations of the season. It seems probable that the young caterpillars appear as new growth buds open, as it is upon this food material that the tiny caterpillars feed. The newly hatched caterpillars are quite active and will travel a relatively long distance in search of suitable food. They have a tendency to travel upward which explains the severe injury to the tops of trees. Soon after the first of August (this date will vary for exposures, altitudes and latitudes), the caterpillars become full grown and construct cocoons in which they transform to adult moths. These cocoons are of a thin, tough texture made of silk and hairs from the body of the caterpillar and are attached to all parts of the tree and underbrush. When the cocoon is constructed the caterpillars are quite naked, being devoid of all hairs. In 10 days or 2 weeks after the cocoons are constructed the adult moths appear, eggs are laid, and the generation is complete.

The fact that female moths are wingless does not seem to affect the long-distance spread of this insect. When disturbed or in search of more food, caterpillars will drop to the ground and travel at the rate of about 1 foot per minute. Although this will explain a migration from tree to tree, or an outward spread from a center of infestation, it cannot be used to explain such a wide-spread distribution as apparently occurred during the past season. The only explanation that can be offered is that small larvae are carried long distances by air currents. When disturbed, which could be by wind blowing the top of a tree, the small caterpillars drop upon a fine silken thread that is often 5 or more feet in length. This thread, with the body hairs of the caterpillars, offers considerable wind resistance, and it is apparent that first and second stage larvae could be carried considerable distance by wind velocities of 10 miles or more. It is also possible that caterpillars could be carried on the backs of animals.

Preferred host trees of the Douglas-fir tussock moth are Douglas-fir and grand fir, although other tree species are attacked when occurring in association with them and a shortage of food occurs. However, it is believed that the preferred host trees are required for an epidemic situation to develop.

HISTORY OF PREVIOUS TUSSOCK MOTH INFESTATIONS

The first available record of an outbreak of the Douglas-fir tussock moth occurred at Chase, B.C., in 1918. This outbreak was recorded as having caused severe damage to Douglas-fir. Since that time other outbreaks have been recorded at Vernon, Grand Forks, and Kettle River, British Columbia. It was not until 1927 that this insect was recorded from the United States when a severe epidemic occurred on the Humboldt National Forest in Nevada. This outbreak was in an area of alpine fir, and heavy losses of timber followed. In 1928, outbreaks were recorded on the Idaho and Weiser National Forests of Idaho, and at the Craters of the Moon, Idaho. In 1929, it was found that these infestations were far more extensive than previous reports had anticipated. In Nevada the entire Jarbridge Canyon was found to be infested, and on the Weiser and Idaho Forests some 40 square miles of Douglas-fir were destroyed within these infested areas. At the same time a severe infestation had developed throughout forest areas near Northport, Washington. This outbreak reached its peak on the Colville National Forest in 1930, spread over many square miles and, by actual cruise, destroyed 300,000,000 board feet of commercial timber. In 1935, a few relatively small spots of infestation occurred within the Wood River drainage of the Sawtooth National Forest, Idaho. This outbreak lasted for 4 years, and destroyed considerable areas of Douglas-fir reproduction and mature timber.

PRESENT TUSSOCK MOTH INFESTATION

In 1944, a few small spots of Douglas-fir tussock moth infestation were recorded at different points throughout northern Idaho. These small outbreaks were located at Rathdrum, Troy, Moscow Mountain, and Sandpoint, Idaho, and near Palouse, Washington. A distance of more than 100 miles separated the Palouse and Sandpoint infestations. In 1945, additional spots of tussock moth infestation were recorded at Farragut, Coeur d'Alene, Rathdrum, Worley, and Genesee, Idaho, and there were undoubtedly many others. In all instances these small outbreaks consisted of a few shade or shelter trees around farm buildings or residences. These scattered, spot outbreaks aroused a fear that some place within the general area there was a heavy center of infestation, which had contributed to their development. This possibility was supported by Ranger Powell's report of a severe infestation of some 320 acres near Viola, Idaho. Subsequent to this report, word was received of a smaller, but equally as severe, an outbreak of some 80 acres between Fairfield and Latah, Washington. This outbreak was some 35 miles to the northwest of the Viola infestation.

An examination of these areas in June 1946 indicated that these infestations were far more severe than anticipated from previous reports. It was not until an aerial reconnaissance had been made that the full magnitude of this infestation was understood. Although it was expected that the infested area would be larger than reported, the size of the infestation as shown by the aerial survey was not foreseen.

The magnitude of the 1946 infestation of the Douglas-fir tussock moth can best be appreciated by examining the map attached to this report. The external boundaries of the infested areas extend southeastward from Tensed, Idaho, for a distance of 50 miles to a point a few miles northwest of Orofino, Idaho. The total area is broken up by non-host forest types and agricultural lands but contains 350,000 acres of 1946 tussock moth infestation. Douglas-fir and white fir, the preferred hosts of the Douglas-fir tussock moth, are found in pure stands and in mixture with ponderosa pine and larch. Pure stands of Douglas-fir, regardless of size or age, apparently contribute most to a heavy defoliation.

Within the Douglas-fir and white fir timber stands of this area, the infestation varies from practically a 100-percent defoliation to what has been called a light infestation. There is a large acreage of light infestation where the injury has been confined to the extreme tops and limb tips. Although this type of injury is not considered as serious, the damage which can be expected to follow another year's defoliation constitutes a real threat to the future of these timber stands. In addition to the areas of light defoliation where the injury is visible from a reasonable distance, there are large acreages where, although the insects are present, the 1946 injury is negligible. The acreage of this new 1946 infestation is unknown, but its potentials in building to a more serious situation must be recognized.

A survey of this area shows approximately 447,000 acres on which in 1946 the tussock moth was present in variable populations. This acreage is broken down into the following four classifications:

1. Heavy defoliation - injury varies from 50% to practically complete elimination of all foliage — 150,000 acres

2. Medium defoliation - injury varies from a complete defoliation of 3 to 4 feet of extreme top of tree to 50% of total foliage — 70,000 acres

3. Light defoliation - visible damage to new growth on limb tips and extreme top of tree — 130,000 acres

4. Insect present within area but no injury visible — 97,000 acres

OWNERSHIP OF LANDS WITHIN INFESTED AREA

Within the area of the tussock moth infestation are 1,593 individual and cooperation owners. Fifty-seven percent of the total acreage is owned by the U. S. Forest Service, Potlatch Forests Inc., State of Idaho, Milwaukee Land Company, Ohio Match Company, McGoldrick Lumber Company, University of Idaho, Northern Pacific Railroad, Public Domain, and Indian land. Most of these lands are forested and lie within the eastern portion of the area.

The remaining 47 percent lies principally within the western portion of the infested area and is divided into 1,582 individual ownerships. Approximately 77 percent of these lands are classified as agricultural and 23 percent as small farm woodlots.

Seedlings and Saplings

These are the result of 1910 and later burns and from cutting mostly accomplished during the past 30 years. Most of these stands will average 36 years and younger in age.

Non-Forest Cover

These areas consist primarily of meadows and non-producing burns.

TIMBER ANALYSIS - INFESTED AREA

Forest acres outside national forest boundary						
		Average value		Volume board feet		
Type	Acres	Acre	M.B.M.	Per acre	Total	Total value
Merchantable	130,363		*2.85	8M	1,042,904M	$2,972,276.00
Pole, seedling and sapling	157,653	**2.20				346,836.00
Non-forest cover	111,942					
Total merchantable pole, seedling, and sapling	288,016					$3,319,112.00

Forest acres inside national forest boundary						
		Average value		Volume board feet		
Type	Acres	Acre	M.B.M.	Per acre	Total	Total value
Merchantable	59,494		*2.85	8M	475,952M	$1,356,463.00
Pole, seedling and sapling	75,741	**2.20				166,630.00
Non-forest cover	9,850					
Total merchantable pole, seedling, and sapling	135,235					$1,523,093.00

Total forest acres inside and outside national forest boundary						
		Average value		Volume board feet		
Type	Acres	Acre	M.B.M.	Per acre	Total	Total value
Merchantable	189,857		*2.85	8M	1,518,856M	$4,328,739.00
Pole, seedling and sapling	233,394	**2.20				513,466.00
Non-forest cover	121,792					
Grand total merchantable pole, seedling and sapling	423,251					$4,842,205.00

* The average value per M was obtained by weighted average of recent appraised stumpage values for all species representative of this area.

**Average value per acre for young growth was determined by values set forth in Land Exchange Guide, R-1, on basis of approximate acreage falling in each price group.

LAND OWNERSHIP WITHIN INFESTED AREA BOUNDARY

Owner	National forest boundary					
	Inside		Outside		Total	
	Acres	Percent	Acres	Percent	Acres	Percent
U. S. Forest Service	62,405	43	43,765	10.94	106,170	19.48
Public Domain	0	0	3,695	.93	3,695	.68
Indian Land	0	0	1,600	.40	1,600	.29
State of Idaho	13,780	9	40,820	10.21	54,600	10.02
University of Idaho	160	.001	5,000	1.25	5,160	.95
County	820	.006	7,470	1.87	8,290	1.52
Potlatch Forests Inc.	25,985	18	54,215	13.56	80,200	14.71
Northern Pacific Railroad	3,740	3	80	.002	3,820	.70
Milwaukee Land Company	6,760	5	4,320	1.08	11,080	2.03
McGoldrick Lumber Company	2,390	2	2,765	.69	5,155	.95
Ohio Match Company	0	0	7,660	1.92	7,660	1.41
Others*	29,045	20	228,568	57.15	257,613	47.26
Total	145,085	100	399,958	100	545,043	100

*Approximate number owners - Inside national forest boundary = 163
Outside national forest boundary = 1,419
Total number owners 1,582

ECONOMIC IMPORTANCE OF TIMBER STANDS WITHIN AND ADJACENT TO INFESTED AREA

Present Situation

Forest lands within the infested area are the most highly productive forest lands in the Inland Empire. Throughout this area a large percent of the white pine and cedar, which are the most valuable tree species, have already been removed leaving an abundance of so-called secondary species. Of the total annual wood consumption (624,000 MBF) throughout this area, approximately 80 percent of the finished and rough products are ultimately shipped to outside markets. Saw logs comprise the greatest percent (77%) of this annual consumption, with poles, mining timbers, pulp wood, posts, and shingles as the secondary items. Fuel wood, mostly Douglas-fir and larch accounts for some 72 percent of the volume used for local consumption.

Merchantable Values

To place an economic value upon the timber stands threatened by this outbreak, data were obtained from the St. Joe National Forest. These data show the acreage and present value of the merchantable timber stands throughout the infested area. These data are shown in the following table.

Merchantable Timber Stands

These stands are composed of mixed species predominating in fir and larch.

Pole Stands

The bulk of this classification is a product of the 1889 burn and averages approximately 55 years in age.

it is evident that the insects were building to an epidemic population in 1935. This outbreak continued until 1938, with an annual increase in the size of the infested area and the severity of the defoliation. Although fairly large numbers of caterpillars were present in 1938, none were in evidence the following season. Outbreaks which occurred prior to the Sawtooth infestation were not followed as closely, although they apparently adhered to the same general behavior pattern. If one applies this past infestation cycle to the present situation, a severe defoliation can be expected in 1947, with considerable reduction in 1948, and practically a complete cessation in 1949. However, it has been stated that the size of the existing infestation leaves one with little assurance upon which to predict its future behavior.

Some factual data were obtained as to the percent of the 1946 brood destroyed by parasites. These studies were of a necessity limited to adult emergence from 1946 pupal cases. Many caterpillars are destroyed prior to the construction of their pupal cases, as a result of larval diseases, starvation in heavily defoliated areas, and from the attacks of predacious insects. These studies were directed so as to obtain a figure of parasitism for the three degrees of defoliation. These data were as follows:

Heavy defoliation	40.4 percent
Medium defoliation	42.0 percent
Light defoliation	11.8 percent
Average for all areas	30.5 percent

This figure implies that from every one hundred 1946 cocoons 70 adult moths emerged. Granting an equal sex ratio, there would be 35 females for each hundred 1946 caterpillars which matured and constructed pupal cases or cocoons. This is not a high degree of parasitism and it is possible that the data obtained from our laboratory tests are much lower than that which actually occurred in the field. The significance of these data can be appreciated when one considers the insects' potential rate of increase. The number of eggs in each cluster or mass will vary from 70 to 100 or more. As many as 178 eggs have been counted in a single cluster, but it is quite possible that eggs from more than one female were involved. As many as 122 eggs have been counted in the abdomen of a single female. Such a potential rate of increase would offset a high percent of parasitism and permit an infestation to maintain or to increase its destructive population.

To obtain further information concerning the potentials of the 1947 infestation a study of the overwintering egg mass population was conducted during the latter part of October. This study was made possible through the temporary detail of seven forest officers from the regional office of the Forest Service at Missoula. These officers, with two employees from the Forest Insect Laboratory at Coeur d'Alene, spent 9 days in obtaining comparative counts of 1945 and 1946 egg masses, and in most instances 1946 pupal cases or cocoons. This work was slow and meticulous, as it was necessary to fell trees and examine thoroughly every bit of foliage as well as the limbs and bole. Samples were obtained from all portions of the areas, representing all degrees of area defoliation, different tree species, and degrees of individual tree defoliation within each area sampled. The data obtained vary from marked reductions in heavily defoliated areas to outstanding increases in lightly infested zones. In some areas new 1946 infestations were recorded with no evidence of 1945 infestation, which prohibited the establishment of any percent of change. Although these data varied from a -97 to as much as +1929 percent the average potential increase for the entire area is approximately 450 percent. While this figure is somewhat questionable, it is sufficiently

It is estimated that should the timber within the infested area be destroyed, approximately 5 percent of the merchantable volume and none of the young growth could be salvaged. This would place the total loss at $4,625,769.00, with a possible salvage of $216,436.00 or approximately 76M M.B.M. It must be recognized that these figures involve the Douglas-fir-larch type, and that the latter species is not threatened by this outbreak. Data were not available to permit the separation of these tree species.

Potential Loss 1947

Should the existing tussock moth infestation spread to new areas in 1947 in proportion to what occurred in 1946, the result would seriously threaten the sustained yield plan of the St. Joe National Forest. Lying within the forest boundary and to the east of the present infestation is an area of 385,912 acres of merchantable fir, which is the preferred host of the tussock moth. On this area, of which 50 percent is national forest land, there are 1,182,000,000 feet of commercial Douglas-fir and white fir. A conservative figure of $2.00 per M places a stumpage value of $2,364,000.00 upon this timber stand.

Economic Justification for Control

The question may well be raised as to the justification of such a large expenditure as will be needed for controlling this epidemic. An unquestionable valuation of the benefits to be derived from control is difficult. Some of the trees which will be killed will be overmature, and would have perhaps died from other causes prior to their utilization. Unlike fire, insect damage usually attacks one or more species, therefore, only partial watershed values and temporary losses in recreation are at stake. In connection with this project it would seem that the cost of insect control must rest upon the preservation of merchantable trees until such time as they can be harvested. Therefore, it must be upon the expectation value of the timber stands at stake that this control job be judged sound or unsound as a public investment.

FUTURE OF EXISTING TUSSOCK MOTH SITUATION

The future of the Douglas-fir tussock moth infestation, which during the past season reached a severe epidemic status within forested areas of North Idaho, is difficult to foresee. Past records show that outbreaks of this insect have been unpredictable as to time or place. Furthermore, there are no records of an outbreak of this magnitude which leaves one with no precedent upon which conclusions can be drawn as to its behavior.

The Douglas-fir tussock moth is undoubtedly native to the northwestern United States. Under normal conditions its population is held at a nondestructive level by its natural enemies. Outbreaks occur when some abnormal environmental condition occurs which allows it to increase to a population above that of its enemies. Most destructive insects have a high potential rate of increase, and take quick advantage of any reduction in the control exerted by natural forces. The duration of such outbreaks is dependent upon the length of time required for the restoration of a balanced environmental condition. There are a number of possibilities which might be offered in explanation for the occurrence of this epidemic. However, all of them would be subject to question and without significant proof.

The last outbreak of the Douglas-fir tussock moth was recorded on the Sawtooth National Forest in 1936. As at that time some fairly large spots of defoliated trees were in evidence, which increased in size as the season progressed,

accurate to indicate that in over 90 percent of the infested area, the egg potentials indicate a marked increase in the 1947 insect population over that which existed in 1946.

In considering this situation there is a possible secondary or follow-up damage which can become extremely destructive. This danger rests in the increased activity of the Douglas-fir beetle (Dendroctonus pseudotsugata). Although this beetle is considered as a primary enemy of mature Douglas-fir trees, it displays a marked preference for Douglas-fir trees weakened through defoliation. A few attacks have already been recorded and it is possible that throughout the severely defoliated areas this beetle may complete the destruction started by the tussock moths.

ARTIFICIAL CONTROL

In combatting foliage feeding insects there are several accepted methods of artificial control. These methods consist of stomach poisons applied to the host plant; contact poisons applied to the insect itself; fumigants which are released within the infested area as a gas; repellents which are applied to the plants to be protected; and attractants which are used in drawing insects to poisonous baits. In most instances these methods of treatment consist in applying the substance as a dust or spray, depending upon the insect to be destroyed.

When one considers the size and the nature of the terrain throughout the infested area with which we are concerned, it is quite obvious that aerial spraying offers the only feasible possibility, and this in itself may be questioned. Aerial spraying provides a better coverage with less material than can be obtained with present ground equipment. In fact, no explanation is necessary to explain the impossibility of ground spraying.

The substance to be used in connection with this project would be a DDT spray applied at the rate of 1 pound per acre. The formula to be used is as follows:

1 pound Technical DDT
1 pint Velsicol
Fuel oil no. 2 to make 1 gallon

It has been suggested by the Bureau of Entomology and Plant Quarantine that effective results may be obtained with a much lighter dosage than 1 pound per acre.

FEASIBILITY OF AERIAL SPRAYING

As has been stated, the only known practical means for controlling an insect epidemic of this character is by aerial spraying. Although this method of treating outbreaks of forest defoliating insects has been successfully accomplished for smaller areas, no attempt has been made to treat an area of such magnitude as the existing tussock moth infestation.

To determine the practicability and probable cost of this project, the reaction of two private flying companies was obtained as to their willingness to fly at elevations of from 50 to 200 feet above the tree tops which is necessary for effective spraying. Accordingly, Mr. Johnson of the Johnson Flying Service, Missoula, Montana, and Mr. Pouline, president of the Central Aircraft Company, Yakima, Washington, were contacted and their opinions requested as to the practicability of using both large and small capacity airplanes in

spraying the area in question per above requirements. After flying over the area they expressed their opinion that the flying was entirely feasible and that they would be interested in bidding upon this project in the event control is to be instituted.

Physical Factors Affecting Decision to Institute Control

In addition to the feasibility of treating this area there are many other physical factors which must be studied to fully understand this problem. The most important of these are as follows:

1. Acreage requiring treatment
2. Terrain
3. Available landing fields
4. Available rail heads
5. Types of planes needed
6. Pay loads
7. Flying distances
8. Altitudes and flying speeds
9. Spray equipment
10. Most effective time of day for aerial spraying
11. Calendar days available for spraying
12. Amount of spray per acre
13. Techniques of aerial spraying
14. Estimated flying cost per acre
15. Available spraying material

1. Acreage Requiring Treatment

There is a total of 350,000 acres of tussock moth infestation which will require treatment.

2. Terrain

Within the infested area the elevation varies from 2,500 to 5,000 feet. Within this area the Palouse River, Potlatch Creek, Dicks Creek and their tributaries are the principal drainages. Throughout the western and southern half of the area are farm lands, small woodlots, and isolated nonhost timber types. Most of the slopes are long and not too abrupt, although there are many small canyons, especially on the eastern portion, which are deep and narrow. These units will require considerable study as variations in elevation and exposure will have considerable bearing in planning proper flight strips. The aviators who studied this area do not feel that it offers insurmountable flying problems.

3. Available Landing Fields

Landing fields located within the infested area and suitable for use of small capacity planes are situated at Tekoa, Washington, Orofino and Elk River, Idaho. However, more landing strips will be required if the spraying job is to be completed within the allowable time. These fields must have a width of 100 feet and a minimum landing strip of 1,700 feet, with a clear approach of 1/2 mile at both ends of the field. Their locations must be accessible by road for supplying spray materials, and centrally located to the areas to be treated, in order to reduce the amount of ferrying time to a minimum.

8. Altitudes and Flying Speeds

Experiments conducted by the Bureau of Entomology and Plant Quarantine have shown that good coverage and swath width may be obtained at heights of 100 to 200 feet above the tree tops. When possible, spray should be applied across wind so as to allow for maximum drift. Spray applications should not be attempted when the wind velocity is over 10 miles per hour and preferably not more than 7. The most desirable height is set at 100 feet but this must be governed by safety. In flying rough terrain it will be necessary to fly at 200 feet or more at times to have an adequate safety factor. Larger planes must fly higher than small planes for safety. Higher speeds cause finer atomization and therefore wider swaths at higher altitudes. Planes flying at 150 feet at speeds of 150 per mile or better have obtained swaths of 700 to 1,000 feet in width. In general, a C-47 flying at 150 feet with cross winds of 5 to 7 miles per hour will cover a swath 5 chains wide. Small planes flying at 70 to 80 miles ground speed will produce swath widths of from 80 to 100 feet. When using plane speeds under 100 miles per hour special breaker bars or other mechanical means of atomization must be employed to obtain effective droplet size for good coverage.

9. Spray Equipment

There are different types of spray equipment which are effective in spraying from airplanes. Obviously, the equipment will vary with the different types of planes in order to obtain a satisfactory atomization and distribution of the spray. None of this equipment is described in this report as this phase of the project must be worked out by the successful contractor under the direction of the Bureau of Entomology and Plant Quarantine.

10. Most Effective Time of Day for Aerial Spraying

Under normal flying conditions the most successful results will be obtained by spraying in the early morning and late evening. During the heat of the day excessive evaporation of spray occurs and flying conditions are generally most difficult and dangerous. In general, early morning spraying is considered the most desirable as strong winds are usually less prevelant than during the late evening.

11. Calendar Days Available for Spraying

The only effective period for this method of treatment is during the feeding period of the tussock moth caterpillars. Treatment should be completed as soon as is possible after the eggs hatch in order to avoid the voracious feeding of the rapidly growing caterpillars. The overwintering eggs hatch in late May or early June, depending upon seasonal variations. It seems probable that the young caterpillars appear with the opening of the new growth buds. To avoid as much injury to the infested trees as possible, it seems advisable to plan for the completion of this project in a 30-workday period. It is recognized that unforeseen factors may require additional time.

12. Amount of Spray Per Acre

The formula recommended by the Washington office of the Bureau of Entomology and Plant Quarantine is 1 pound of DDT to 1 gallon of fuel oil per acre.

High speed and large capacity planes require hard-surface graveled runways of 5,000 feet and clear approaches of 1 mile or more. To construct such runways would not be practical or physically feasible during the short period of construction time available. If large planes are used they will have to base their operations from either the Pullman-Moscow field or from the airport at Lewiston, Idaho. The Lewiston field is so far distant that its use would not be practicable. This leaves the Pullman-Moscow field as the only suitable field available from which large capacity planes can successfully operate.

4. Available Rail Heads

Throughout the area are many rail heads that could be used for storage and handling of spray material. Tensed, Bovil, Troy, Elk River, and Moscow, Idaho, are all suitable for distributing points. Technical DDT is a powder which must be dissolved with a solvent before being mixed with fuel oil. With an estimated maximum amount of 17,500 gallons required daily, a central storage and mixing plant would be most desirable. As the largest volume of spray will be needed at the Moscow-Pullman field, the logical location for the mixing plant and the storage of materials would be at Moscow, Idaho. Five large tankers mounted on semi-trailers of 4,000 gallons capacity will be needed for spray distribution. It is also possible that a number of small tankers of 2,000-gallon capacity can be used to transport the mixed spray to small outlying fields.

5. Types of Planes Needed

It has been suggested by a private spraying company that this area can be most successfully treated by small and large capacity airplanes. It was also suggested that helicopters could be used to advantage in certain rough terrains. Large capacity airplanes are more economical and efficient for spraying large areas but are limited by the availability of suitable landing strips. Small capacity planes can operate from small landing strips but are not economical if flying distances are too great. Helicopters can use almost any open clearing but so far are limited in use on account of their low capacity pay load.

6. Pay Loads

The amount of spray which can be carried will vary from a minimum of 600 pounds (75 gallons) to 3 ton (750 gallons), depending upon the type of planes used. Small, one-motor ships will normally carry a pay load of 600 pounds. Ford tri-motor ships carry 3,000 pounds and C-47's a 6,000-pound pay load.

7. Flying Distances

The maximum distances from the Moscow-Pullman airfield to the extreme limits of the infested area will not be over 40 miles air line. Only large capacity planes should use this field. Small capacity ships must operate from fields not more than 10 air miles from the area to be treated if they are to be effective. Small fields, suitable for these light planes, must be located within the area. While cow pastures, meadows, and farmers' grain fields are scattered throughout the area, considerable difficulty is expected in obtaining proper locations. No trouble is expected to be encountered in obtaining permission from private owners for use of such fields.

13. Techniques of Aerial Spraying

The pilot is responsible for the proper coverage of an assigned area and the success of the operation will depend upon how well this phase of the project is performed. He must be thoroughly familiar with the pattern of the spray produced by the aircraft he is flying for different heights and wind velocities. He should be trained so that he can fly even swaths without assistance from the ground. In some areas, flag men may be necessary and in heavily wooded areas meteorological balloons may be anchored. Radio communication from the plane to the ground would be of advantage in directing the work.

If control is to be instituted for this infestation, complete sets of aerial photographs must be made available for the entire area. They should be vertical and corrected to a common scale. Mr. J. B. Yule of the Forest Service regional maps and surveys office states that he is of the opinion that the entire proposed area to be treated has been photographed and prints may be obtained from the negatives already available.

14. Estimated Flying Cost Per Acre

Past project costs for airplane spraying (cost of flying only) have varied from 50 cents per acre up to $2.50 per acre, depending upon location, size of area, and spray equipment available. In an area of this magnitude with treating units ranging in size from 10 to 10,000 acres, and varying in shape from regular blocks to long, narrow streamers, with air fields located long distances from the infested areas, there will be considerable noneffective flying time. Furthermore, some consideration must be given to the equipment risk involved and to the hazardousness of the operation. After analyzing all the factors, it is estimated that the flying costs should vary from 60 cents per acre on the most accessible areas to $1.00 per acre for the less accessible units or an over-all average of about 80 cents per acre. This figure contemplates that the planes, spray equipment, mixing of spray materials, and distribution of spray will be performed by the contractor under the technical direction of the project leaders.

15. Available Spraying Materials

Present information indicates that the supply of Technical DDT is limited and will be difficult to secure in such large quantities as will be needed. Out of 19 chemical companies contacted, 10 failed to answer, 7 answered no stock, 1 had no Technical DDT and offered an alternative, and 1 company said they could supply DDT but failed to state in what amounts.

Required amounts of Velsicol AR-50 and fuel oil no. 2 are available for purchase in sufficient quantities.

COST OF OPERATION

The following statements of costs are in some instances based upon factual data obtained from private airplane companies, chemical companies, and the R-1 wage classification scale, and in others upon our best estimates:

PROJECT COSTS

Materials		
350,000 lbs. Technical DDT at .60 per lb.	= $210,000.00	
306,000 gals. Fuel Oil No. 2 at .10 per gal.	= 30,600.00	
43,750 gals. Velsicol Solvent at .54 per gal.	= 23,625.00	
Total Material Costs	$264,225.00	$264,225.00
Flying Costs*		
350,000 acres at $0.80 per acre	= $280,000.00	280,000.00
Landing Strips		
10 fields at $2,000.00 per field	= 20,000.00	20,000.00
Overhead and Adm. Costs		
1 Project Leader 8 mo. and exp.	= 4,500.00	
1 B. of E. Technical Advisor 4 mo. and exp.	= 3,300.00	
1 Supply Clerk 2 mo. (3644.80)	= 590.00	
1 Clerk-Typist 2 mo. (2168.28)	= 512.00	
	8,902.00	8,902.00
Pre-Control Crews		
1 Foreman 4 mo. (2650)	= 884.00	
4 Strawbosses 4 mo. (2166)	= 720.00	
4 Crewmen 4 mo. (1902)	= 632.00	
	2,236.00	2,236.00
Checking Field Spraying		
1 Foreman 2 mo. (2650)	= 442.00	
4 Strawbosses 2 mo. (2166)	= 360.00	
4 Crewmen 2 mo. (1902)	= 316.00	
	1,118.00	1,118.00
Spray Plant Checkers		
4 Crewmen 2 mo. (1902)	= 316.00	316.00
Transportation Costs		
12 Pick-ups - 40,000 miles at .08	= 3,200.00	3,200.00
Miscellaneous Items		
Photographic Prints, Aerial Survey, Subsistence of Crew Personnel, etc.	= 15,003.00	15,003.00
	Grand Total	$595,000.00
	Cost per acre	1.70

*Includes planes, pilots, spraying cost, mixing and distribution of spray.

POSSIBLE HARMFUL EFFECTS OF DDT ON TREATED AREAS

Considerable discussion has occurred relative to the possible harmful effects of DDT. Questions have been asked as to the effects of the proposed treatment upon fish, game birds, and wild animals, as well as domestic animals and drinking water. These questions are not peculiar to this project but have occurred on all large-scale DDT operations. It is obvious that we will be obliged to turn for correct answers to those who have studied these problems. Some data have been obtained and temporary answers offered for these many

questions. However, information concerning the use of DDT is changing rapidly, and a final decision as to the possibility of a dangerous biological disturbance must rest with the Washington office of the Bureau of Entomology and Plant Quarantine.

As far as available information indicates, the small dosage necessary to control forest insects will not have any injurious effects upon drinking water. In spraying along contours and across streams the light dosage is not expected to have any harmful effects upon fish. Further, it is not considered that such treatment will result in any permanent biological aftermath or disturbance.

The suggested treatment will destroy some of the insect life which is active within the area at the time of treatment. This has raised a question as to the possible detrimental effects of destroying the natural enemies (predators and parasites) of the tussock moth. It is possible that it will destroy a percent of these insects which are active at that time. However, during the early stages of tussock moth caterpillar development, some of the beneficial insects will not be in an active status and should escape destruction. Although this treatment will not be expected to exterminate the natural enemies of the tussock moth, it is a factor which must be considered.

SUMMARY OF FACTORS RELATING TO THE INSTITUTION OF CONTROL

In considering the advisability of instituting artificial measures for the control of the existing tussock moth infestation, and as one views the defoliated areas, it would seem that this outbreak must be stopped at any cost. Unfortunately, the answer is not that simple. To arrive at a proper decision there are a number of important questions or issues to be met. These questions can be grouped into three classifications, namely, economical, physical, and entomological. Although most of them have already been discussed, some are of sufficient importance to warrant repetition in this summary. These items under their classifications follow:

Economic Factors

All apparent economic phases of this project have been rather thoroughly discussed within this report and require no repetition. It has been properly stated that control must stand upon the present and expectation value of the timber stands at stake. An economic justification has been shown for this project, which of a necessity has been based upon the full value of the timber stands at stake. Obviously, in even the severely defoliated areas many trees will escape destruction. Douglas-fir will suffer most from this defoliation, although many injured trees will recover. In considering the possible destruction of timber, each year that defoliation continues a greater proportion of the injured trees will die. Concern is not so much with the damage that has occurred, but with the effects of further defoliation in 1947.

An item of no small importance will be the increased fire hazards resulting from areas of dead timber. No attempt is made to evaluate the importance of this item in its relation to the justification for control other than to recognize its existence. It is of interest to know that the timber protective associations of this area are greatly concerned over this possibility.

Physical Factors

There are many physical difficulties associated with the aerial spraying of an area of such magnitude as the existing tussock moth infestation. Most of these items have been previously discussed, but the importance of some of them will permit a brief repetition. The volume of spray (17,500 gallons) to be applied daily to complete the project within imposed time limits; the lack of air fields to permit an efficient operation; and the complete stymying of the project through inadequate supplies of DDT, are factors which will be vital to the success of control. It is true that the project is considered physically feasible, but this consideration does not remove the many problems and difficulties associated with it.

Entomological Factors

In considering the entomological soundness of artificial control, there are a number of factors that have received careful consideration.

Effectiveness of Treatment - It is assumed that aerial treatment with DDT will destroy the caterpillars of the Douglas-fir tussock moth. This treatment has been used successfully against such insects as the gypsy moth, hemlock looper, and the spruce budworm. It has been demonstrated that ground spraying with DDT will give desired results against the tussock moth. This fact is not fully significant as during ground operations a far greater volume of spray material is used than from aerial treatment. Laboratory tests, planned to assimilate the proposed aerial treatment against tussock moth caterpillars, gave entirely satisfactory results. So, although it can be strongly assumed that this treatment will be successful, as it has never been tested, no positive assurance can be given. This doubt arises from the fact that some insects, without any tangible reason, are immune from the effects of DDT. The institution of this project would of a necessity be regarded as somewhat experimental.

Future or Duration of Existing Infestation - Control measures instituted in 1947 will be directed against an outbreak which in a year or more will undoubtedly be reduced by beneficial biological forces. The difficulty of predicting with full assurance the future of this outbreak has been discussed. Data from comparative counts of 1945 and 1946 egg masses show for the entire area an increase of 450 percent. Perhaps this figure should not be accepted at full value as predictions based upon egg populations can be seriously upset by subsequent egg mortality. This possibility is recognized, but it is a risk that has been assumed in predicting the future of this outbreak. Within the next few weeks an attempt will be made to obtain some data concerning egg mortality. However, as some egg parasites are not active until a short time before the eggs hatch, data obtained at this time will not be complete.

Regardless of the questionable nature of the data available, it is predicted that there will be an epidemic population of tussock moth caterpillars in 1947, and that the associated damage will be as severe, if not more so, than that which occurred in 1946. It is not difficult to foresee what another year's severe defoliation will do to trees within the now heavily defoliated areas. It will also mean that the now medium and most of the lightly infested areas will become heavily defoliated areas. What will occur in 1948 is a question which cannot be foreseen at this time.

Effects of Treatment Upon Beneficial Biological Factors - The fact that the proposed treatment may destroy beneficial parasitic and predacious insects

as well as tussock moth caterpillars has been fully considered. Obviously, the destruction of such beneficial forces of natural control is something to be avoided whenever possible. However, it is a condition associated with most control projects, and is not as serious as when first considered. During the early stages of a control project directed against the small caterpillars of the tussock moth, most parasitic insects would be in an inactive status. Within their places of overwinter pupation or hibernation, they would no doubt be safe from the effects of DDT. Furthermore, it can be assumed that the destruction of both tussock moth caterpillars and beneficial insects would be in equal ratio to their populations. If this occurred there will remain after control the same biological balance as existed at the time of treatment, only at a much lower population level. So, although this is a factor to be considered, at this period in the infestation cycle of this insect it is not too serious a factor in determining the advisability of control.

RECOMMENDATIONS

The seriousness of the tussock moth infestation as described within this report warrants the institution of artificial control. It is recognized that regardless of this reaction there may still be some unforeseen economical or physical item which will prohibit the institution of this project, either in total or in part.

There are 350,000 acres of tussock moth infestation which warrant the institution of control. It is recommended that this entire area be included in any plan of operation. Throughout the zones of heavy infestation there are some small areas where the potentials of the 1947 brood would not seem to warrant the cost of control. To establish the boundaries of such areas for the purpose of eliminating them from the project would be a difficult and expensive task. Furthermore, in considering the advisability of such action, it is recognized that although the 1947 brood potential is low, so is the foliage complement remaining upon the now injured trees. As a result, a light caterpillar population could result in the complete defoliation of all trees within such areas and, obviously, in their ultimate death.

Some thought has been given to the possibility of treating specific units and protecting them by a so-called buffer strip around the outside. The purpose of such buffer strips would be to absorb any infestation which might spread from untreated areas toward the protected units. The success of such action is difficult to foresee but one may be assured such buffer strips would have been of little value during the past season. It is therefore recommended that in considering the possibilities of control the plan of operation include all areas regardless of ownership, past defoliation, or potentials of 1947 insect population.

It is possible that this recommendation for the treatment of the entire 350,000 acres cannot be accepted because of some economic or physical condition which cannot be met. It may be that only a portion of the total area can be treated, and that it would be advisable to proceed on such a basis. Although such action would be better than the abandonment of the project, it is sincerely trusted that it will not be necessary because of its entomological unsoundness. To meet such a reduced operation, it is recommended that the 150,000 acres of heavily defoliated areas receive first priority. This selection is based upon the hopes of saving many trees within the heavily defoliated areas and on the chance that the infestation within the more lightly infested zones will be reduced by natural enemies before serious losses occur.

CONCLUSIONS

In the preparation of this report it is recognized that some factors have been presented in considerable detail while, apparently, others have been neglected. In the first instance this detail has been considered necessary to present a full picture of the situation. In the second instance it is because further data are not available.

If this project is to be instituted, a final decision should be made at an early date. There are many things to be done before this operation could be instituted; things which are time consuming and laborious. It is therefore desired to stress the necessity of an early decision as to the institution of this operation.

SUPPLEMENTAL JUSTIFICATION DATA

Social Values at Stake - Infested Timber

Infested timber amounting to 1,518,000 M board feet represents potential employment possibilities at the rate of 20.7 man-hours per M, or 31,440,000 man-hours.

At $1.00 per man-hour, this is equivalent to a pay roll loss of $31,440,000. At current lumber values of $40 per M f.o.b. mill, the value of the infested timber in the form of lumber is 1,518,000 x $40, or $60,754,000. If, for lack of control measures, infested timber is killed, local government will suffer annually in reduced taxes by the amount in private ownership. Roughly, this is estimated to represent 50 percent of the total or 759,000,000 board feet. At current tax rates of approximately 5 cents per M, this is equivalent to an annual tax loss of 759,000 x .05, or $37,950.

Threatened Timber

Volume of additional timber threatened by the infestation is estimated at 1,182,000 M board feet. Logging and milling requires 20.7 man-hours of labor per thousand board feet. This represents potential local employment of 24,467,000 man-hours or a potential pay roll of $24,467,000 at current wage rates. Value of threatened timber in the form of lumber, at current f.o.b. mill prices of $40, is $47,280,000.

Approximately 50 percent or 592,000 M board feet of threatened timber is in private ownership and an important part of the local tax base. Loss of this timber may result in an annual tax loss of 592,000 x .05, or $29,600.

Total Social Values at Stake

	Pay rolls	Lumber value	Annual taxes
Infested timber	$31,400,000	$ 60,754,000	$37,950
Threatened timber	24,467,000	47,280,000	29,600
Total	$55,867,000	$108,034,000	$67,550

Farm Forestry

Unfortunately, the area where the infestation is heaviest is in the heart of the most promising farm forest zone in Region One. Already there has been some expression of discouragement among the farm forest owners. Doubtless another year of heavy insect attack will prove a decidedly damaging blow to the development of a promising private forestry program that is just budding in the Latah-Benewah Counties area. Besides the farmer group, two industrial concerns, the Milwaukee Land Company and Potlatch Forests, Inc., have already embarked on ambitious forestry programs. Both have extensive holdings in the infestation zone. Failure or inability to conduct control measures followed by another severe year of damage certainly would be a stumbling block in the way of private forestry here, and it could well have an adverse effect over a wide area.

Fire Control Implications

According to present indications, this infestation will seriously affect fire protection of the area involved. Before infestation, green larch-fir type is classed as medium rate of spread and medium resistance to control. Fire protection in such types approximates 9 cents per acre per year. If 50 percent of the stand is bug killed, it creates a high-high fuel which costs something like 12 cents to 15 cents per acre for protection. Last year's bug invasion on 350,000 acres can well have raised the cost of fire protection at least $21,000 per year. This increase in hazard will continue for 30 or more years. Hence, the increase in cost would amount to $630,000 in addition to an increased risk to adjacent timber stands.

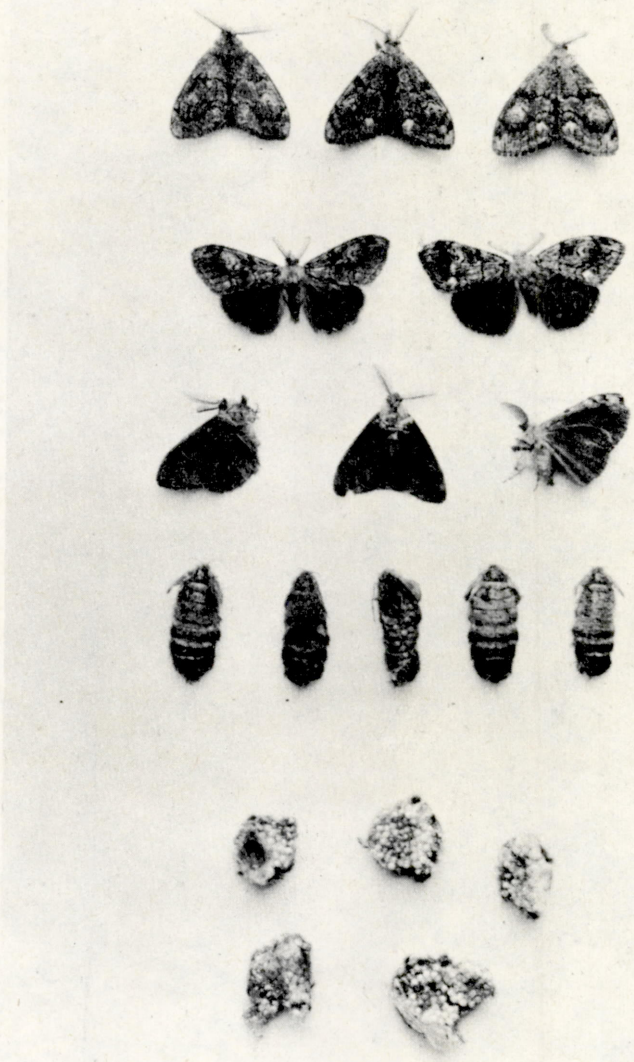


Figure 1

Adult male and female moths and detached egg masses of the Douglas-fir tussock moth

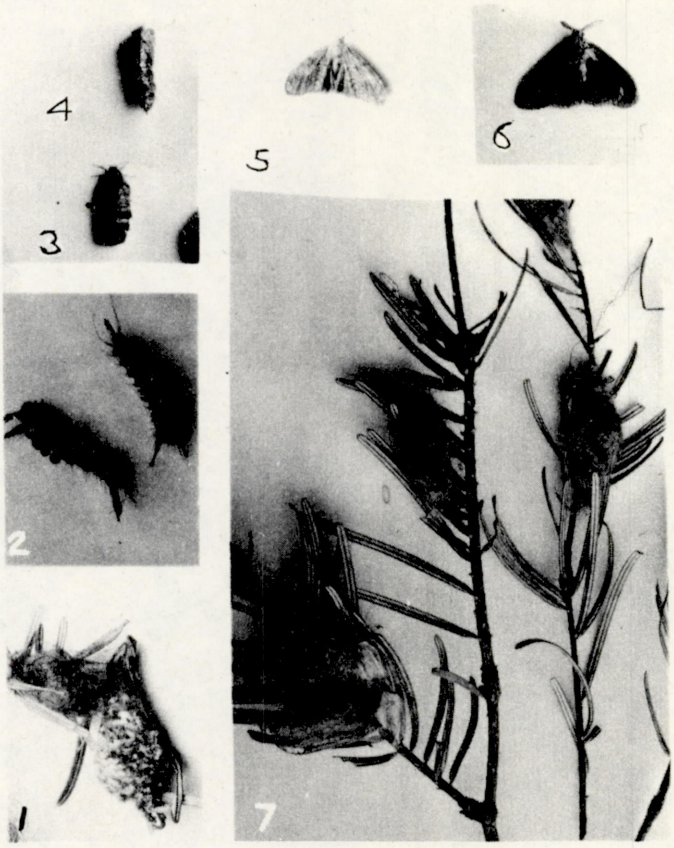


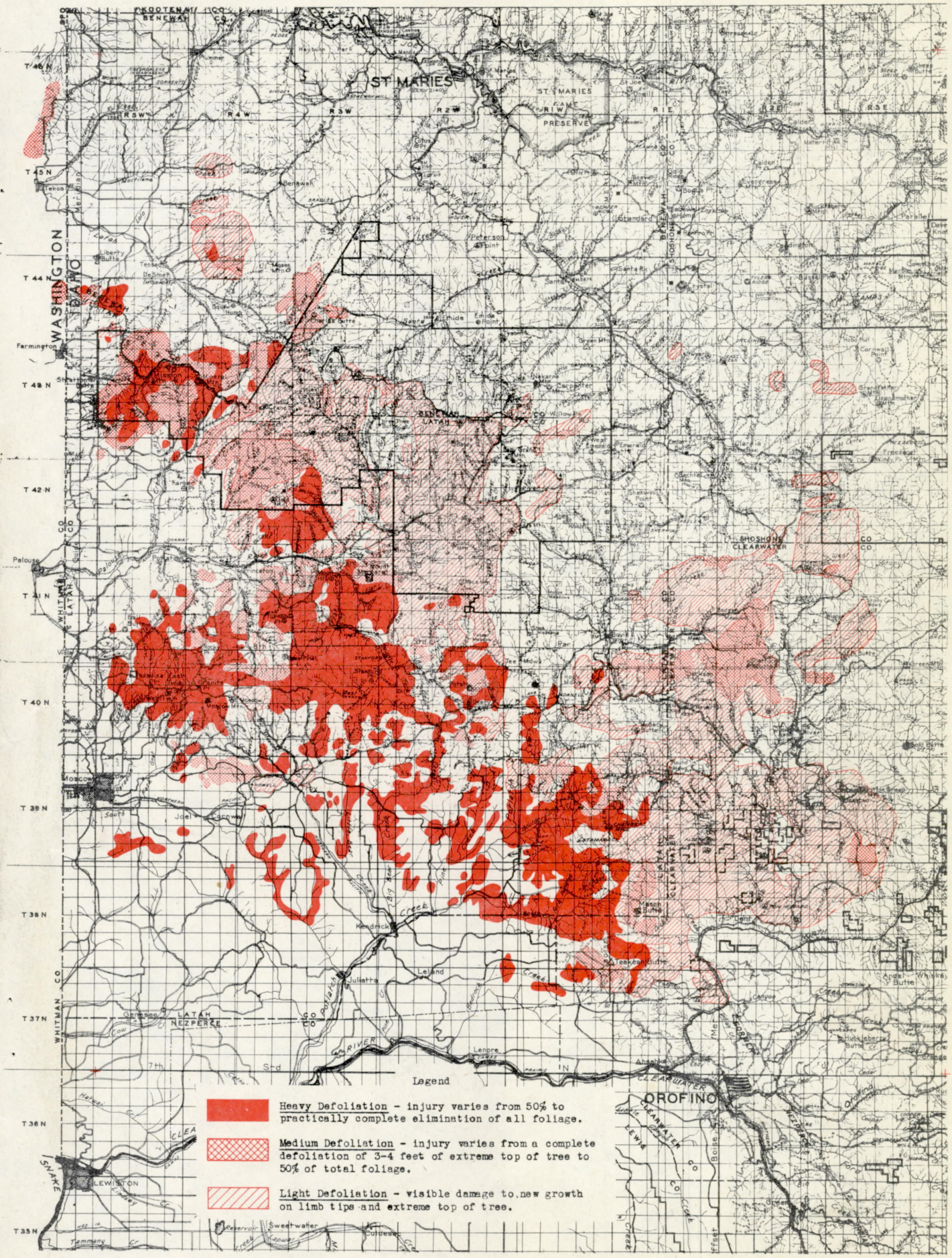
Figure 2

Douglas-fir tussock moth

1. Egg mass
2. Caterpillars
3. Adult female
4. Pupal case
5. Adult male
6. Adult male
7. Cocoons

Figure 3

Cocoons and egg masses of the
Douglas-fir tussock moth


ST MARIES
ST. MARIES RIVER
PRESERVE
WASHINGTON
IDAHO
BENEWAH CO
SHOSHONE CO
LATAH CO
SHOSHONE CLEARWATER CO
WHITMAN CO
NEZPERCE CO
CLEARWATER CO
LEWIS CO
Farmington
Palouse
Moscow
Kendrick
Juliaetta
Leland
Genesee
LEWISTON
OROFINO
SNAKE
CLEARWATER
Legend
Heavy Defoliation - injury varies from 50% to practically complete elimination of all foliage.
Medium Defoliation - injury varies from a complete defoliation of 3-4 feet of extreme top of tree to 50% of total foliage.
Light Defoliation - visible damage to new growth on limb tips and extreme top of tree.